NATIONAL BUREAU OF STANDARDS REPORT

7423

PERFORMANCE TEST OF A "ULOK"
REPLACEABLE MEDIA CUBE-TYPE AIR FILTER

manufactured by
Union Carbide Development Company

by

Carl W. Coblentz and Paul R. Achenbach

Report to

Public Buildings Service
General Services Administration
Washington 25, D. C.

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Mechanical Systems Section
Building Research Division

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1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of two specimens of a cube-type air filter using a replaceable media, were determined. The scope of this examination included the determination of the pressure drop and dust holding capacity of the specimens, and the determination of the arrestance of Cottrell precipitate and the particulate matter in the laboratory air.

2. DESCRIPTION OF TEST SPECIMENS

The test specimens were manufactured and supplied for test purposes by the Union Carbide Development Company of New York, New York, and were identified as their "Ulok" Cube-type Air Filters.

The filter media consisted of a mat approximately 1 3/4 in. thick and shaped like a cube. The outside dimensions of this cube were about 20"x20"x8" with one 20"x20" side open for the inlet of the air. The effective area of the filter media was approximately 5 sq ft. According to the manufacturer, the media was made of acrylic fibers which were found by a flame test not to sustain combustion. A microscopic examination showed the individual fibers to be approximately 50 microns in diameter and 3 inches long. The media was treated with an adhesive and weighed 440 grams, approximately 1 lb., without the frame. The frame furnished for the filters consisted of an inner and an outer basket, both made of 1/8" steel wire. In assembling the filter, a lip on the open side of the media was pulled over the inner basket and clamped against the outer basket to prevent air from leaking around the filter mat. The 8-inch sides of the cube were tapered to allow the air to flow away freely from the downstream side of the media when a number of individual filters are arranged in a bank. The degree of taper was such that the 20-inch square inlet area was reduced to a 17-inch square at the back panel.

3. TEST METHOD AND PROCEDURE

The filters were tested at the rated air flow rate of 1,000 cfm. The arrestance determinations were made with the NBS Dust Spot Method described in a paper by R. S. Dill entitled "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938). The filter under test was installed in the test apparatus and carefully sealed to prevent any by-pass of air or inward leakage into the test apparatus, except through the measuring orifice. After establishing the correct air flow rate through the filter, samples of air were drawn from the center points of the test duct 2 feet upstream and 8 feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. Arrestance determinations were made with the particulate matter in the laboratory air as the aerosol and also with Cottrell precipitate injected into the air stream in a ratio of 1 gram per 1,000 cu ft of air.

The light transmission of the sampling papers was measured on the same portion of each paper before and after the test and the two sampling papers used for any one arrestance determination were selected to have the same light transmission when clean.

For determining the arrestance of the particulate matter in the laboratory air equal sampling areas were used in the upstream and downstream samplers. A similar increase of the opacity of the two sampling papers was obtained by passing the sampling air through the upstream paper only part of the time while operating the downstream sampler continuously. This was accomplished by installing a solenoid valve in the upstream sampling line and another one in a line by-passing the sampler. The solenoid valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, and reversing the position of the two valves during the remainder of the cycle. The arrestance, A (in percent), was then determined with the formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T was the percentage of time during which air was drawn through the upstream sampler, and ΔU and ΔD were the observed changes in the opacity of the upstream and downstream sampling paper, respectively.

For determining the arrestance of the filter with Cottrell precipitate as the test dust, different size areas of sampling paper were used upstream and downstream of the filter in order to obtain a similar increase of opacity on the sampling papers. The arrestance was then calculated by the formula:

$$A = \left(1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U}\right) \times 100$$

where the symbols A, ΔU, and ΔD have the same meaning as indicated above and S_U and S_D are the upstream and downstream sampling areas, respectively.

Arrestance determinations were made at the beginning and at the end of the test of each specimen filter and at several intermediate loading conditions. Lint was not fed to the filter while arrestance determinations were made with Cottrell precipitate, but lint was added during alternate periods of the loading process in a ratio of 4 parts to every 96 parts of Cottrell precipitate, including that amount of Cottrell precipitate used for arrestance measurements. The Cottrell precipitate had been previously sifted through a 100-mesh screen and the lint was prepared by grinding No. 7 cotton linters through a Wiley mill with a 4-millimeter screen.

The pressure drop across the filter under test was recorded at the beginning of the test of each specimen, after each arrestance determination, and after every 20-gram increment of Cottrell precipitate that was introduced into the test duct. The tests were terminated when the pressure drop across the filter reached 0.5 in. W.G.

4. TEST RESULTS

The results observed during the tests of the two specimens are presented in Table 1 which shows the pressure drop, dust load, the arrestance of Cottrell precipitate and of the particulate matter in the laboratory air.

Table 1

Performance of Union Carbide
"ULOK" Cube-Type Air Filter at 1000 cfm

Specimen No. 1

Pressure Drop in. W.G.	Dust Load grams	Arrestance** percent Aerosol A	Arrestance** percent Aerosol B
.113	0	67*	12
.154	156	73*	14
.210	414	77	12
.278	620	81*	11*
.312	724	82	--
.384	930	84*	19*
.446	1086	88*	29*
.505	1199	86*	28*

Specimen No. 2

Pressure Drop in. W.G.	Dust Load grams	Arrestance** percent Aerosol A	Arrestance** percent Aerosol B
.107	0	71*	7*
.182	252	76*	--
.263	514	84	14
.334	704	89	19
.381	810	91*	21
.448	907	89*	26
.507	992	89	25

* Average of two or more tests.
**Aerosol A is Cottrell precipitate.
Aerosol B is the particulate matter in the laboratory air.

The "dust load" shown in this table is the weight of dust received by the filter, at that time. It represents the amount of Cottrell precipitate and lint introduced into the test apparatus, diminished by the percentage of dust fallout upstream of the filter. This dust fallout was determined at the conclusion of the test of each specimen by weighing the dust that had been swept out of the upstream part of the test duct and calculating the percentage of the total weight of dust introduced represented by the fallout.

The values of Table 1 are presented graphically in Fig. 1 in which the pressure drop, the arrestance of the particulate matter in laboratory air and of Cottrell precipitate are plotted against the dust load as smooth curves approximating the lines of the least mean square distances of the respective points of observation. It is noted that the pressure drop of specimen 1 increased from 0.113 in. W.G. with a clean filter to 0.505in. W.G. after a dust load of 1199 grams had reached the filter. The arrestance ofparticulate matter in the laboratory air increased gradually from 12% to 28% while the arrestance of Cottrell precipitate increased from 67% to 86% during the loading period.

The pressure drop of specimen No. 2 increased from 0.107in. W.G. to 0.507in. W.G. after a dust load of 992 grams had reached the filter. The arrestance of particulate matter in the laboratory air increased gradually from 7% to 25% and that of Cottrell precipitate from 71% to 89% during the loading period. The dust holding capacity, i.e., the dust load of the two specimens at 0.5 in. W.G., according to the lower curves in Fig. 1 was 990g and 1190g, respectively.

The two specimens of the same type were tested to determine the uniformity of the media. A general agreement of their performance is evidenced by the similarity of the three pairs of curves in Fig. 1, although it will be noted that the arrestance of Specimen No. 2 was somewhat higher than that of No. 1 for Cottrell precipitate, accompanied by a faster rise of its pressure drop curve.

Table 2 presents a summary and the average values of the test results obtained with the two specimens, as taken from the curves.

Table 2

Summary of Test Results

	Spec. #1	Spec. #2	Average
Pressure Drop, clean, in.W.G.	0.113	0.107	0.110
Dust Holding Capacity, grams	1190	990	1090
Arrestance, percent			
Clean, Cottrell precipitate	68	71	69
Clean, Laboratory Air	12	7	10
Loaded, Cottrell precipitate	88	89	89
Loaded, Laboratory Air	29	25	27
Mean, Cottrell precipitate	80	82	81
Mean, Laboratory Air	17	15	16

UNION CARBIDE CORPORATION "ULOK" AIR FILTER

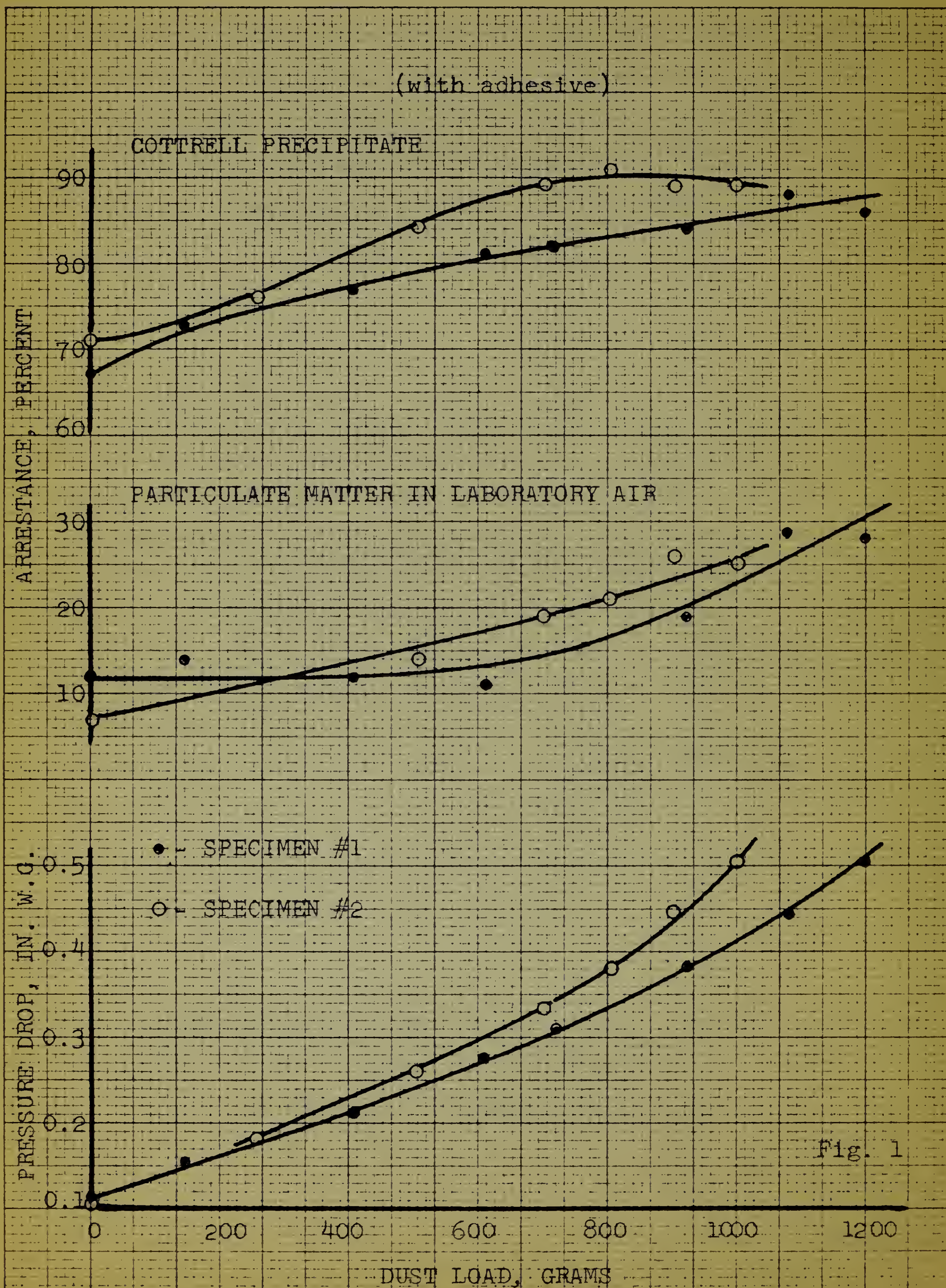

Fig. 1

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics. Electrolysis and Metal Deposition.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Crystal Growth. Physical Properties. Constitution and Microstructure.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Solid State Physics. Electron Physics. Atomic Physics.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Molecular Kinetics. Mass Spectrometry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Interval Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

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